

SARCOPTIC MANGE IN INDIAN GOAT AND SHEEP SKINS AND ITS EFFECT ON LEATHER

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Sarcoptic mange-infested goat and sheep skins have been examined to describe the condition of the lesion on the raw skin, together with the gross changes of the lesion, if any, during beamhouse operations. Histopathological changes in the raw goat skins due to sarcoptic mange and variations in physical and chemical properties of the affected areas of the skin and leather have also been studied. Amino acid composition of the affected area has been compared with that of the adjacent unaffected area of the skin.

Introduction

Sarcoptic mange¹⁻³ is caused by *Sarcoptes caprae*/*Sarcoptes scabiei* var *caprae* in goat skins and by *Sarcoptes ovis*/*Sarcoptes scabiei* var *ovis* in sheep skins. Similar members of the genus *Sarcoptes* affect several other species of hosts¹⁻⁵ such as man, cattle, horse, camel, swine, dog, rabbit, fox, lion, llama and wombat. In ferrets they give rise to a disease called as rot or foot rot. Human beings handling infested cattle become affected with a dermatitis called 'Dairyman's itch'.

'The catalogue of Mites of India' by Prasad¹⁰ has shown that there are many reports on this parasite causing the mange; but a detailed report on the effect of this mange on sheep and goat skins and on leather made out of such skins is lacking. Therefore factors such as gross appearance of the lesion on the raw skins, gross variation in the appearance of the lesion during beamhouse operations, histological variation,

amino acid composition of the lesion affected area of the raw goat skin and the physical and chemical properties of the leather were considered for study.

Materials and methods

From about 60,000 sheep and goat skins examined for various surface defects,¹¹ one sheep and 58 goat skins were collected from sheep and goat slaughter house, Perambur, Madras and brought to the laboratory for further examination.

Microscopical examination of the aetiological agent

Deep scrapings from the margins of the lesion were collected boiled in 10 per cent KOH for 5 to 10 minutes, cooled, centrifuged and the sediment was microscopically examined for parasites.

Vegetable tanning

The wet salted skins were soaked for 3 hr., limed with 2 per cent sodium sulphide and

8 per cent lime for 2 days with handling thrice fleshed, a day. The skins were unhaired, relimed for 5 days with 10 per cent lime, followed by washing and deliming. The pelts were pickled lightly with 0.5 per cent sulphuric acid and 8 per cent salt (NaCl) for 30 min. and then tanned with wattle extract, gradually increasing the strength of the tan liquor from 8° BK to 20° BK. Tanned skins were then myrobed followed by oiling with 3 per cent pungam oil and hooked up for semidrying. Later, they were subjected to setting, trimming and buffing.

Chrome tanning

Delimed pelts were pickled with 1 per cent sulphuric acid, 8 per cent sodium chloride and 200 per cent water and later chrome tanned with 10 per cent B & C chrome powder, basified with sodium bicarbonate to pH 3.9 and piled. The tanned skins were neutralised with 0.75 per cent sodium formate to pH 5.5, followed by fat liquoring with Sandozol KBS (2.5 per cent) and raw castor oil (1 per cent) and finally converted into crust leather.

Histopathological techniques

Mange affected goat skin pieces (1 sq. cm) fixed in 10 per cent formalin were embedded in paraffin blocks and sections of about 5 μ were made with a rotary microtome. Such sections were stained¹² by haematoxylin and eosin and also by van Gieson's method.

Physical properties of vegetable and chrome tanned leathers

Physical properties¹³ such as tensile strength, elongation, stitch tear resistance and tongue tear resistance were determined by tensile strength tester for light leather (Scott tester) for the affected areas of the leather and the results compared with adjacent unaffected areas. Similarly, SATRA

grain crack values were determined by the 'Lastometer'.

Determination of the shrinkage temperature of leathers and of the raw collagen fibres in the lesion affected areas.

Shrinkage temperatures of various leathers were determined using Theis shrinkage meter. The collagen fibres of the affected and unaffected areas of the skin were teased out in water and placed on a shrinkage testing meter¹⁴ with a regulated temperature rise of 3°C per minute and the temperature at which the fibres started shrinking was recorded.

Chemical properties of sarcoptic mange affected leathers

Oil and fat content, chrome content, hide substance and degree of tannage of the mange affected portions of leathers were determined and compared with the data obtained for normal portions.

Amino acid analysis

Samples of the skin (one each from affected and unaffected portions) were taken separately and hydrolysed with 6N HCl in a sealed hydrolysis tube at 110°C for 22 hr. The contents were evaporated at 50°C by using a rotary evaporator under reduced pressure to dryness. The residue was dissolved in a sodium citrate buffer (pH 2.2) to a suitable volume and then subjected to amino acid analysis in a Beckman Amino Acid Analyser 120 C model.

Results

Morphology of sarcoptes caprae

Eggs (Fig. 1) are oval and greyish-white in colour with an average size of 166 μ in length and 93 μ in breadth. (Egg of *Sarcoptes ovis*-length 163 μ and width 94 μ)

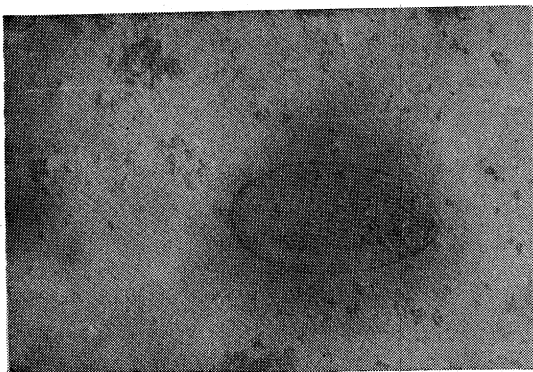


Fig. 1: Ovum of *sarcoptes caprae* opt Mag 100X

The larvae possess three pairs of legs and are smaller in size. The average size is 187μ in length and 139μ in breadth. (Larva of *Sarcoptes ovis*-length 168μ and breadth 115μ).

The nymphs possess four pairs of legs and in contrast with adult mites the body is covered with numerous bristles. Average size is 220μ in length and 183μ in breadth. (Nymph of *Sarcoptes ovis*-length 245μ and breadth 188μ).

The body of the adult female mite is globose or tortoise like with an average size of 369μ in length and 284μ in breadth. (Adult female of *Sarcoptes ovis*-length 384μ and breadth 269μ). It shows a large number of small setae and bristles on the dorsal surface. It has also two vertical setae on the dorsum of the propodosoma. The proboscis of the mite is horse shoe shaped. Small bell shaped suckers (caruncles) are situated on long stalks (pedicels) on the tarsi of the first and second pairs of legs. The legs are short and thick, the posterior two pairs well within the margin of the body. The third and the fourth pair end in bristles instead of suckers. The anus is situated terminally. Adult females lodging the eggs are oviferous females (Fig. 2).

The males are smaller in size (length 218μ) and Breadth 167μ (Size of *Sarcoptes ovis*-length 196μ and breadth 155μ).

The posterior margin is smooth and not bilobed. The first, second and fourth pair of legs only have the suckers. No adanal suckers (copulatory discs) are present among the males.

Observations on raw skin

The infested skin becomes rough, thickened, and comparatively heavier than the normal skin of the same size. Invariably in all the affected skins, the hind shanks (Fig.3) have been found to be infested and show greater thickness due to the heavily deposited scab. Sarcoptic mange-infested skins were usually picked out from a particular lot of freshly slaughtered skins by closely observing the lesions on the hind shanks and also by the unusual heaviness of the skins.

Apart from this observation, the lesion affected areas on the grain side of the main body of the goat skins (Fig.4) and sheep skins (Fig. 5) showed a great amount of closely packed, adherent epidermal scabs with criss-cross tunnels running in various directions on the surface of the skin. The lesions were more frequent on the hind shanks, butt, abdomen, shoulder and neck, but only in heavily infested skin the back or lumbar region was also affected. The affected areas were devoid of hair and rough to touch with numerous folds and plicas.

In certain instances where there was extensive damage the epidermis appeared to be severely eroded, exposing the underlying corium. Probably the presence of such eroded areas on the skin was due to mechanical damage caused by rubbing of the skin on inanimate objects by the host animal while alive.

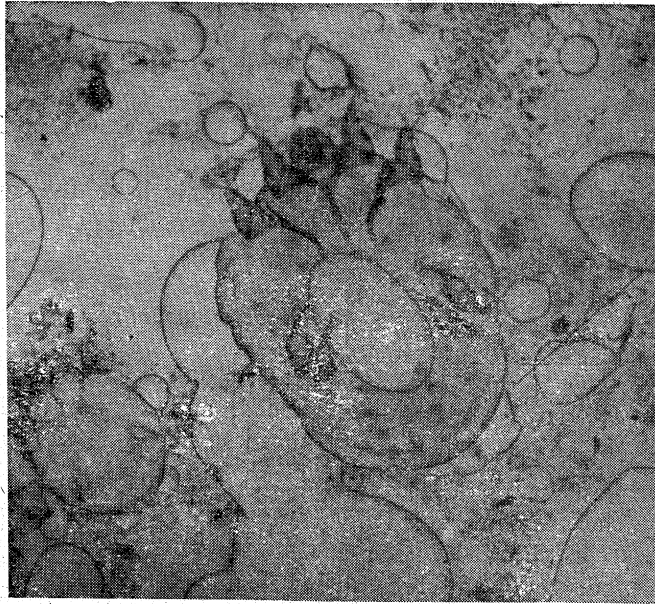


Fig. 2: Ovigenous female of *Sarcoptes caprae* X 100 X

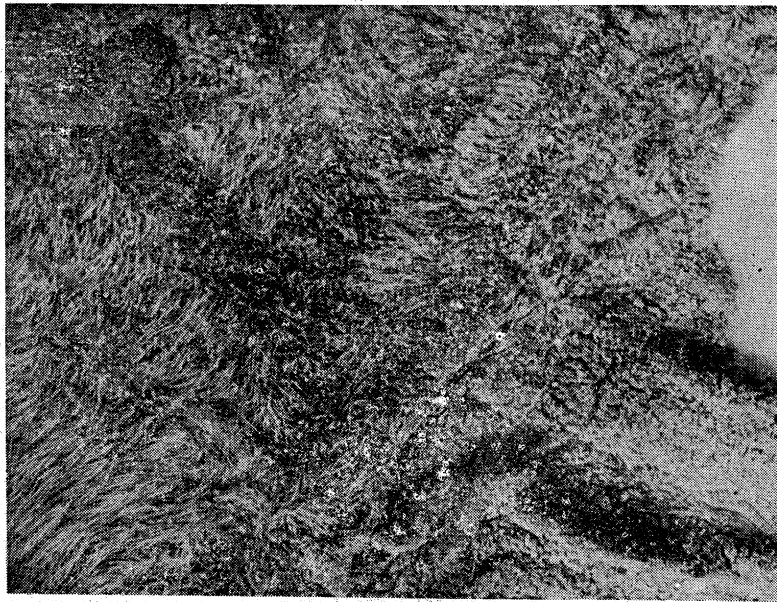


Fig: 3 : Thickening and heavy deposition of scab due to sarcoptic mange on the hind shank of goat skin



Fig. 4 : Appearance of the sarcoptic mange infested portion of the goat skin, showing heavy deposition of scabs, tunnels and alopecia

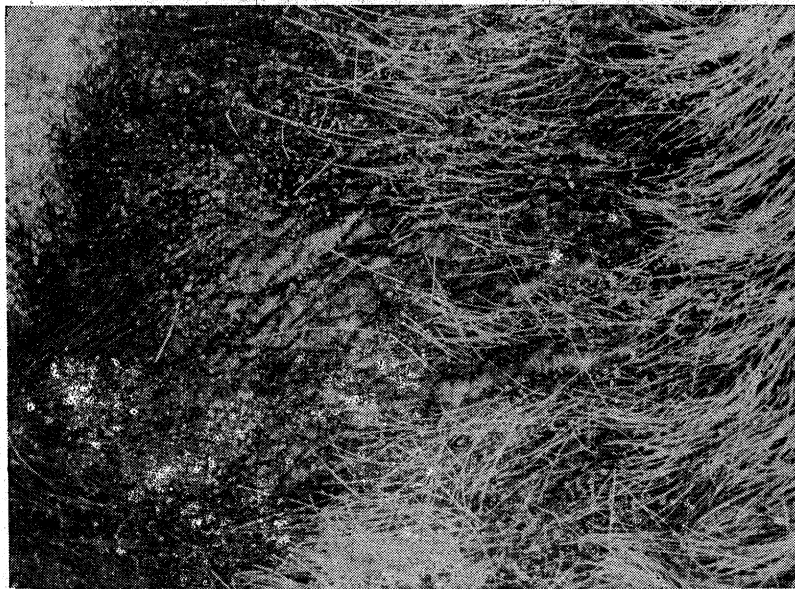


Fig. 5 : Appearance of sarcoptic mange infested portion of the sheep skin

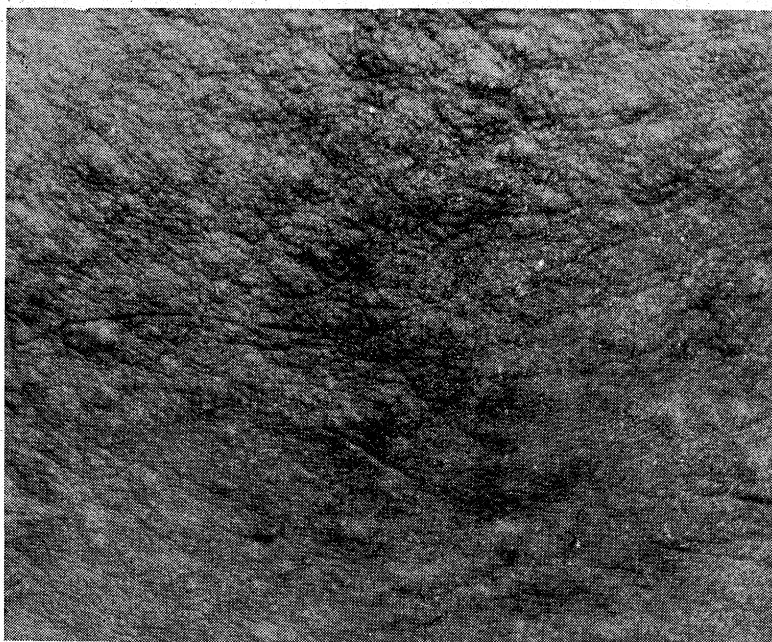


Fig. 6: Criss -cross tunnel seen on the grain side of the limed pelt of goat skin due to sarcoptic mange

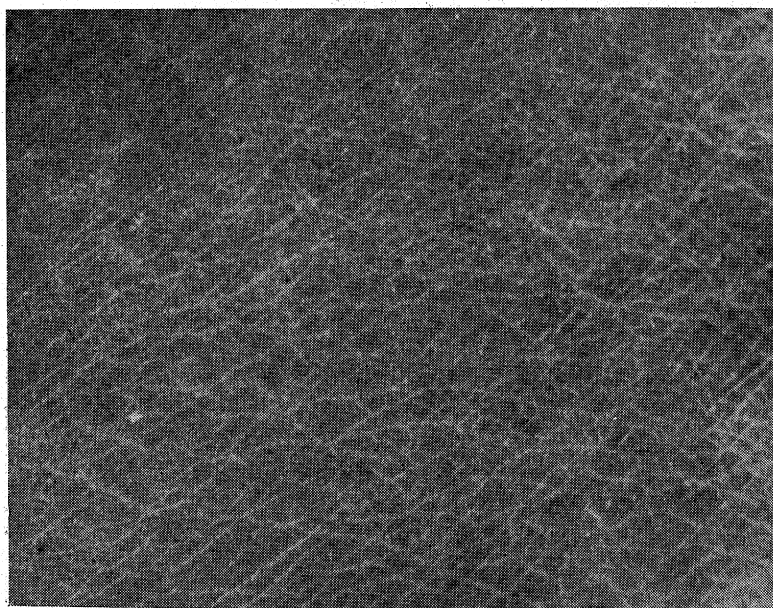


Fig. 7: Tanned leather showing the lesion due to sarcoptic mange

Physical properties of chrome and vegetable tanned leathers made out of sarcoptic mange-affected goat skins

<i>Skin No</i>	<i>Tensile Strength Kg/sq. cm.</i>	<i>Percent elongation at break</i>	<i>Tongue tear resistance Kg/cm thickness</i>	<i>Stitch tear resistance kg/cm thickness</i>
<i>Chrome tanned</i>				
170 con	152 . 7	50 . 0	44 . 4	128 . 5
170 Aff	112 . 3	30 . 0	22 . 7	90 . 7
174 con	287 . 4	42 . 5	18 . 6	115 . 5
174 Aff	281 . 2	35 . 0	18 . 6	90 . 5
176 con	277 . 5	35 . 0	20 . 0	123 . 5
176 Aff	162 . 9	22 . 5	15 . 1	115 . 9
179 con	226 . 8	37 . 5	18 . 6	115 . 5
179 Aff	195 . 8	37 . 5	13 . 2	119 . 6
186 con	168 . 0	42 . 5	13 . 6	86 . 2
186 Aff	164 . 2	27 . 5	18 . 1	90 . 2
<i>Vegetable tanned</i>				
169 con	272 . 2	30 . 0	11 . 5	118 . 6
169 Aff	280 . 9	25 . 0	12 . 2	98 . 8
175 con	312 . 4	37 . 5	11 . 3	111 . 5
175 Aff	236 . 4	32 . 5	11 . 3	124 . 7
177** con	194 . 7	32 . 5	10 . 3	90 . 7
177** Aff	171 . 0	30 . 0	17 . 8	94 . 5
178** con	229 . 1	30 . 0	12 . 5	95 . 3
178** Aff	280 . 9	25 . 0	11 . 3	85 . 5

Con = Control Aff = Affected

** Mixed infestation due to Psoroptic mange mites also.

TABLE 2a
Satra grain crack values

TABLE 2b
Grain crack and bursting resistance

Skin No	Control				Affected				Grain Crack resistance* Kg/cm thickness		Bursting resistance* Kg/cm thickness	
	Grain Crack		Bursting		Grain Crack		Bursting		Control	Affected	Control	Affected
	Ext mm	Load kg	Ext mm	Load kg	Ext mm	Load kg	Ext mm	Load kg				
10	7.8	15.3	8.9	21.3	7.9	15.3	8.7	18.7	191.25	170.00	266.25	207.77
50	6.6	14.7	9.1	36.0	6.0	11.0	8.5	23.3	163.33	122.22	400.00	258.88
136	7.6	13.7	8.5	16.0	7.9	14.7	9.5	22.7	274.00	210.00	320.00	324.28
170	7.7	32.0	8.5	37.3	7.5	24.0	8.7	31.3	355.55	218.18	414.44	284.54
174	6.9	25.3	7.8	34.3	7.7	22.7	8.0	26.0	281.11	206.36	381.11	236.36
176	6.8	19.3	7.9	30.0	7.6	29.3	8.2	33.3	241.25	293.00	375.00	333.00
182	8.6	36.0	9.9	54.3	7.6	21.0	9.7	46.7	300.00	190.90	452.50	424.54
277	6.2	14.0	8.7	33.3	6.9	15.7	9.1	25.3	175.00	196.25	416.00	316.25
366	7.9	16.0	10.1	32.7	7.6	10.7	10.8	26.7	200.00	133.75	408.75	333.75
367	6.9	13.3	9.4	29.3	7.4	19.3	8.7	26.0	166.25	241.25	366.25	325.00
373	6.4	14.7	8.3	31.3	6.2	17.3	7.4	22.7	245.00	247.14	521.06	324.28
374	7.0	15.3	9.7	38.0	7.2	14.7	10.7	33.3	191.25	163.33	475.00	370.00

The grain crack extension in all the cases are more than 6.0 mm and therefore found to be satisfactory. However, the grain crack resistance and bursting resistance values are usually less among the affected samples of leather as compared with their corresponding controls.

Grain crack values :

6.0 mm and below : Sub standard
7.0 mm : satisfactory
8.0 mm and above : very good

*Grain crack resistance
or
*Bursting resistance = $\frac{\text{Load (Kg)}}{\text{Thickness (cm)}}$

The lesion affected areas (Fig. 6) on the pelt were evident only on the grain side. There were large numbers of criss-cross tunnels giving rise to a check pattern. The tunnels were tortuous. The affected portions were thinner and rougher in texture, than the normal plumped portion of the skin and were tinted dark bluish-black in colour.

Observations on tanned leathers

In tanned leathers (Fig. 7) the affected areas were rough, thin, brittle and papery in appearance. Such affected areas continued to show the dark bluish-black tint among chrome tanned leathers, but those on the vegetable tanned leathers were dark brown in colour. The large number of criss-cross tunnels or depressions were clearly evident on the grain surface.

Histopathological observations of the affected raw skin

Parakeratosis and hyperkeratosis of the epidermis were the predominant features. The compressed and atrophic nature of the dermis in affected areas of the skin was clearly evident as compared with the dermis of the adjacent normal portion of the skin, accompanied by round cell infiltration in the upper third of the dermis. The collagen fibres of the dermis, in the affected portions, were stained dark reddish-brown by van Gieson's method of staining, indicating their degeneration.

Physical and chemical properties of affected leathers

Physical properties such as tensile strength, per cent elongation, tongue tear resistance, stitch tear resistance (Table 1) SATRA grain crack values (Table 2 a and 2 b) of chrome tanned leathers and shrinkage temperature

of vegetable and chrome tanned leathers (Table 3) have been ascertained as also the shrinkage temperature of the raw collagen (untanned) fibres.

TABLE 3

Shrinkage temperature of untanned fibres and crust leathers from Sarcoptic mange infested goat skins

<i>Shrinkage Temperature</i>	<i>Control (°C)</i>	<i>Affected (°C)</i>
<i>Untanned fibres</i>		
Maximum	61.0	60.0
Minimum	59.0	58.0
Average (12)*	60.4	58.5
<i>Chrome tanned leathers</i>		
Maximum	125.0	121.0
Minimum	110.0	108.0
Average (12)*	115.8	113.6
<i>Vegetable tanned leathers</i>		
Maximum	84.0	82.0
Minimum	78.0	77.0
Average (6)*	81.7	79.8

* No. of samples in parenthesis

Chemical properties such as chrome content of the chrome tanned leathers and hide substance of the vegetable tanned leather, together with the estimation of oils and fats in both the types of leathers were determined and the results are presented in Table 4. The degree of tannage has also been ascertained to determine the uptake of vegetable tannins and the data are presented in Table 5.

Seven out of the nine experimental samples of the leather crusts have shown lower values of tensile strength for affected areas. Per cent elongation of lesion affected areas was less than in controls in all cases except one, where the value was equal to that of the control sample. The magnitude of the loss of elongation is more in chrome tanned than in the vegetable tanned leathers.

Chemical properties of sarcoptic mange affected leathers made out of goat skins

<i>Chrome tanned leathers at zero percent moisture basis</i>				
<i>Skin numbers</i>	<i>Oils and fat (per cent)</i>	<i>Hide substance (per cent)</i>	<i>Chrome content (per cent)</i>	<i>Chrome content on hide substance basis (per cent)</i>
170 Con	0 . 94	—	7 . 04	—
170 Aff	1 . 30	—	7 . 43	—
174 Con	0 . 56	—	7 . 12	—
174 Aff	1 . 13	—	7 . 57	—
176 Con	2 . 04	—	7 . 27	—
176 Aff	2 . 89	—	7 . 25	—
179 Con	0 . 49	—	8 . 03	—
179 Aff	1 . 23	—	8 . 11	—
186 Con	1 . 15	—	7 . 17	—
186 Aff	1 . 74	—	6 . 97	—
367 Con	4 . 67	—	3 . 83	—
367 Aff	4 . 74	—	4 . 23	—
228 Con	—	62 . 75	5 . 57	8 . 88
228 Aff	—	61 . 28	5 . 75	9 . 88
269 Con	—	61 . 19	5 . 34	8 . 73
269 Aff	—	59 . 59	5 . 56	9 . 33
104 Con	—	61 . 19	5 . 38	8 . 78
104 Aff	—	50 . 24	5 . 10	10 . 15
170 Con	—	65 . 04	6 . 24	9 . 60
170 Aff	—	63 . 01	7 . 11	11 . 28

Con - Control Aff - Affected

<i>Skin numbers</i>		<i>Oils and fats (per cent)</i>	<i>Hide substance (percent)</i>	<i>Hide substance on fat free basis (per cent)</i>
169	Con	8 . 25	43 . 65	47 . 59
	Aff	8 . 49	41 . 96	45 . 85
175	Con	5 . 87	44 . 19	46 . 95
	Aff	8 . 17	44 . 08	48 . 00
177**	Con	6 . 73	44 . 90	48 . 14
	Aff	8 . 56	43 . 45	47 . 52
274**	Con	7 . 44	42 . 33	45 . 73
	Aff	11 . 07	41 . 93	47 . 15

Con = Control Aff = Affected

** Mixed infestation due to psoroptic mange mites also.

TABLE 5
Extent on the degree of tannage

<i>Vegetable tanned leathers at zero percent moisture basis</i>					
<i>Skin numbers</i>	<i>Oils and fat (percent)</i>	<i>Hide substance (percent)</i>	<i>Hide substance on fat free basis (percent)</i>	<i>Fixed organic matter (percent)</i>	<i>Degree of tannage (percent)</i>
440	Con	7 . 07	41 . 55	44 . 76	38 . 61
	Aff	3 . 69	42 . 61	44 . 24	40 . 57
441	Con	4 . 87	44 . 64	46 . 93	37 . 90
	Aff	3 . 72	42 . 02	43 . 64	40 . 93
442	Con	5 . 58	43 . 01	45 . 55	38 . 25
	Aff	4 . 73	41 . 22	43 . 27	40 . 94
517	Con	5 . 87	42 . 75	45 . 42	39 . 20
	Aff	7 . 07	40 . 21	43 . 27	40 . 15

Con - Control Aff - Affected

Values pertaining to tongue tear resistance and stitch tear resistance of the mange-affected portions show considerable variation with no consistent trends.

There is a reduction of micro-shrinkage temperature of affected untanned fibres by 2°C. However, in view of the wide range of the controls—15°C for chrome tanned and 6°C for the vegetable tanned leathers—the T_g of the affected leathers for all practical purposes fit within the range.

The uptake of oils and fats by the affected portions of leather due to sarcoptic mange is greater, both in the chrome and vegetable tanned leathers (Table 4). A similar increased uptake of chrome in affected portions is observed in 7 cases only. Hide substance in the affected portions is invariably reduced to the extent of 0.25 to 18.0 per cent as compared with the normal areas of the same leather. However, the reduced values for hide substance mean not necessarily a reduction of hide substance but more likely the greater uptake of tanning agent and certainly more oil. When the values are corrected on an oil-free basis then the differences are also less and sometimes in the opposite direction.

A determination of the degree of tannage would be interesting and may show whether or not the uptake of vegetable tannins is also affected and the results obtained are presented in Table 5. Higher degree of tannage is observed in the sarcoptic mange affected portions of the leather although the value for the hide substance shows a decreasing trend as compared to their controls. The oil and fat content are less in the affected portions of the leather in contrast to the controls except in one case (Skin No. 517) contrary to the data observed in Table 4.

The amino acid composition of the sample one each of the affected and unaffected portions of the raw skin revealed that the

hydroxy-proline-proline ratio of the affected tissue (0.84) is less than the control (1.06) and the hydroxylysine-lysine ratio (0.17) of the affected tissue is actually double the value obtained for control (0.09). The results on hydroxylysine-lysine ratio are not in conformity with the findings of Comte and Laidet¹⁸ determined with various other defective skins. Analysis of a greater number of samples may be necessary to express the differences as significant.

Discussion

Goat skins are more prone to sarcoptic mange infestation than the sheep skins.

The aetiological agents isolated from all the affected goat and sheep skins appeared to be *Sarcoptes caprae* and *Sarcoptes ovis* respectively based on their gross morphological characteristics.¹⁻⁴ The presence of thick incrustations as scab devoid of hair in affected regions is due to the horny layer of the epidermis as an outcome of parakeratosis and hyperkeratosis. The epidermis is definitely excavated and numerous tunnels are present running in a criss-cross fashion. Such tunnels are produced by the female mite, which burrows deep into the epidermis giving rise to tunnels, before laying eggs and also for feeding on lymph and other tissue fluids. The burrowing is due to the fact that their mouth parts are not as long as those of psoroptids which can even tap the capillary bed¹⁵ as superficial feeders.

On liming, the lesion affected areas appear as criss-cross tunnels; the skin is discoloured and shows less plumping. In vegetable or chrome tanned leathers the affected parts are always rough, thin and papery, showing numerous criss-cross tunnels. The affected portion is also stained dark-brown on vegetable tanned leathers and darker shades of bluish-black on chrome tanned leathers. This

kind of discoloration is probably due to the interaction of the secretion of the mites lodged within the tissue, with the liming and tanning materials. In this context it is of interest to note that psoroptids are capable of producing a toxic secretion.¹⁶

In this connection it would be quite convincing to mention the presence of 881 mites per sq. cm. of skin as reported by Sharma Deorani and Chaudhury⁶ and the length of each tunnel caused by the mite to be upto 15 mm.⁴

Probably because of the presence of large numbers of mites, and due to their active movement giving rise to tunnels, the nerve ends are irritated with ultimate itching. The lesions are caused in the basal epidermal membrane⁴ as a result of which the papillary and also the deeper strata of the integument become involved in the process.

As a result of irritation there is an intense inflammation which is accompanied by serous infiltration of the papillary and epidermal strata. The exudate together with the leucocytes extravasated under the epidermal surface, becomes dried and forms crusts. Stratification of the keratin layer is brought about and causes the appearance of many tunnels and formation of epidermal scabs (Figs. 4 & 5) since the lesions resemble grossly the skin of an elephant,¹ the condition is called popularly 'Yanai Chottai'.

Histopathological studies revealed the presence of parakeratosis and hyperkeratosis of the epidermis as the predominant features. Similar observations were also indicated by Sastry.¹⁷

Because of the considerable thinness and brittleness of the affected portion of tanned skin, there is a reasonable reduction or loss in tensile strength and per cent elongation.

Although the grain crack values in all the cases tested are above 6 mm and said to be satisfactory, the grain crack resistance and the bursting resistance are definitely lower among the affected portions of the leather (Variation in magnitude of such values depends upon the intensity of infestation). It is probable that such leathers may not withstand the pressure involved in fabrication.

The chemical properties of both, the chrome and vegetable tanned leathers show that the affected portions have an affinity for higher intake of oil and fat and the magnitude of such intake is greater and more evident among the vegetable tanned leathers. In spite of this fact, the affected portions have invariably shown brittleness. The chrome content of the affected part shows considerable variation but certainly it is higher than that of the corresponding controls. The hide substance values in the affected part of vegetable and chrome tanned leathers are lower than in the normal portions. Degree of tannage of the sarcoptic mange affected portions have shown higher values than the controls.

An examination was made by Comte and Laidet¹⁸ of various defects in sheep skins, including earth stain (which is supposed to be a form of mange in the opinion of the authors) and they found that the hydroxylysine-lysine ratio was distinctly lower in the defective skins than in the controls. The hydroxylysine-lysine ratio in this paper is actually doubled in the defective portion of the skin as compared with the normal portions of the same skin.

The damage caused to the skin by this defect is considerably extensive and involves large areas. Not only did the gross or apparent lesions devalue the skins but they also affected the physico-chemical properties of the leather to a certain extent.

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REFERENCES

1. Lapage, G., 'Veterinary Parasitology' pp 700, Oliver & Boyd, Edinburgh, Tweeddale court, (1956).
2. Lapage, G., 'Monnigs Veterinary Helminthology & Entomology' Fifth Edition pp 314, Bailliere Tindall & Cassell, London, (1965).
3. Cameron, T. W. M., 'The Parasites of Domestic animals, Second edition pp 328, Adam & Charles Black, London, (1951).
4. Ershov, V. S., 'Parasitology & Parasitic Diseases of Livestock' pp 281, Moscow State Publishing House for Agriculture Literature, (1956).
5. Sen, S. K., Bainbrigge & Fletcher, R. N., 'Veterinary, Entomology & Acarology for India.' pp 523, Indian Council of Agricultural Research, New Delhi, (1962).
6. Sharma Deorani, V. P. & Chaudhuri, R. P., *Ind. J. Vet. Sci. & Animal Husbandry*, 35, 150 (1965).
7. Chauduri, R. P., *Ind. Vet. J.*, 40, 336 (1963).
8. Basu, Menon & Sengupta *Ind. J. Vet. Sci.*, 22, 143 (1952).
9. Dempsey, M. & Robertson, M. E., *J. Internat. Soc. Leather. Trades Chemists.*, 21, 196 (1937).
10. Prasad, V., "A catalogue of mites of India", pp 12, Indira Acarology Publishing house, Ludhiana, Punjab, India, (1974).
11. Venkatesan, R. A., Sugumar, M., Nandy, S. C. & Santappa, M., *Leather Sci.*, 24, 255 (1977).
12. Gurr, E., *Staining of Animal Tissues*, pp, 233 & 243, Leonard Hill (Books) Limited, London, (1962).
13. *Methods of Physical testing of leather*, IS : 5914, 1970. Indian standard Institution, New Delhi, *Official methods of Analysis*, Soc., of Leather Trades Chemists, Croydon, (1965).
14. Borasky, R & Nutting, G. C., *J. Am. Leather. Chemists Assoc.*, 44, 830 (1949).
15. Hughes, T. E., *Mites or the Acari*, p. 48, The Athlone Press, Univ. of London, (1959).
16. Highes, T. E., *Mites or the Acari*, p 324, The Athlone Press, Univ. of London, (1959).
17. Sastry, G. A., *Veterinary Pathology*, P. 565, Venkateswara Press, Tirupati, India, (1969).
18. Comte, P. & Laidet M., *Technicuir*, 10, 171 (1978). *Abst through. J. Soc. Leather. Technol. Chemisis.*, 54, 307 (1970).